Influence of Gavage Tube Characteristics on Gastric Residuals in Preterm Infants

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Abstract

The gastrointestinal tract of preterm infants is developmentally immature placing them at high risk for developing feeding intolerance and/or necrotizing enterocolitis (NEC). Enteral nutrition is provided by gavage tube until the suck-swallow mechanism matures. Standards of care include checking for gastric residuals via aspiration prior to each feeding in order to assess feeding tolerance. The presence of gastric residuals can be indicative of physiologic immaturity or the development of NEC. Thus assessing for the presence of gastric residuals is critical to providing safe care to preterm infants. It is important to identify factors that can impact accurate assessment of gastric residuals. The purpose of this study is to examine the influence of the material used to construct the gavage tube on gastric residual volume. This study used a comparative analysis to determine the influence of gavage tube properties on gastric residual volume. A laboratory setting was used to simulate gavage feeding in preterm infants. Polyurethane and silicone tubes in sizes 5Fr and 6.5Fr were compared. A feeding pump infused 15ml of human breast milk or formula through the tubes into a reservoir that contains a mixture of HCL with a pH of 3.0. Gastric residuals were recorded across ten trials for each feeding tube size, composition (polyurethane and silicone), and type of feeding (human breast milk preterm formula at preselected caloric densities). Comparative analysis resulted in significant differences between silicone vs. polyurethane tubes and formula vs. breast milk. When aspirated, polyurethane tubes and breast milk yielded more volumes than silicone and formula. Inaccurate assessment of gastric residuals might be occurring placing the preterm infant at greater risk for developing feeding intolerance and/or NEC.

Introduction

Prematurity continues to be a significant problem. Approximately 500,000 premature infants are born on an annual basis (Hamilton, Martin, & Ventura, 2011). One of the challenges facing health care providers in managing the care of premature infants in the neonatal intensive care unit (NICU) is the safe provision of enteral nutrition. Initially, enteral nutrition is provided via tube feedings because the majority of premature infants have an undeveloped suck-swallow-breathing reflex that requires their nutritional support to be initiated and maintained by nasogastric/orogastric tube feedings. An important issue that confronts premature infants is the immaturity of their intestinal tract. This places the infant at high risk for exhibiting signs of feeding intolerance as well as the development of necrotizing enterocolitis (NEC). A common clinical indicator used to assess for the development of either condition is the presence of gastric residuals, which is assessed through the aspiration of stomach contents via the feeding tube. Thus, it is critical that the obtained volume of gastric residual is truly representative of stomach contents.

One factor hypothesized to impact the accuracy of gastric residual assessment is the composition of the material used to manufacture the feeding tube. Polyurethane and silicone are the two most common materials used. The type of material used determines the size of the internal diameter of the feeding tube because of differences in the composition properties of the materials. Polyurethane is a harder material when compared to silicone thus the walls of the feeding tube do not have to be as thick allowing for a larger internal diameter (Tingey, 2000). An important consideration is whether the difference in internal diameters will impact the accuracy of gastric residual assessment.

The purpose of this laboratory study was to determine if the material of neonatal nasogastric tubes, polyurethane versus silicone, would impact assessment of gastric residuals. In addition, the impact of size of the external diameter, 5Fr and 6.5Fr, and type of feeding, formula and fortified breast milk, on the ability to assess gastric residuals was examined.

Background and Significance

Fine-bore tubes made of polyurethane or silicone are the most effective type of enteral tubes. There is a reduced incidence of complications associated with their use including pharyngitis, otitis media, and incompetence of the lower esophageal sphincter (Hockenberry & Wilson, 2009). These more flexible tubes cause less irritation to the patient and are less likely to interfere with swallowing than ridged, large-bore tubes (Hockenberry & Wilson, 2009). Despite these favorable qualities, fine-bore tubes present with their own complications. The possibility of collapse when negative pressure is applied may occur when a clinician is aspirating the feeding tube to check gastric residuals (Hockenberry & Wilson, 2009 & Dean, 1983). Collapse of the feeding tube would limit the volume of gastric stomach contents that could be aspirated.

There has been a lack of research focused on the effects of the qualitative differences between silicone and polyurethane feeding tubes. In the only study to examine the effects of feeding tube composition on gastric residuals, Eisenberg et al. (1989) found that polyurethane tubes yielded significantly more aspirated fluid than silicone tubes in sizes 8Fr, 10Fr, and 12Fr. This study also found that the mean volume aspirated was greater in 10Fr tubes than 12Fr tubes, all of which attribute to the need for further examination of tube material and size when assessment of residuals is critical to the patient (Eisenberg et al., 1989).

Because of the limited amount of research focused on material composition of feeding tubes, findings from research conducted comparing silicone to polyurethane in peripherally inserted central venous catheters (PICCs) may shed some light on potential differences in silicone and polyurethane feeding tubes. Polyurethane PICC lines were found to be more rigid and have thinner walls than the flexible silicone PICC lines. Silicone PICC lines had thicker walls and provided more resistance when inserted (Mayer & Wong, 2002). Polyurethane PICCs can withstand higher flow rates and had fewer occlusions than silicone tubes (Angle et al., 1997; Di Giacomo, 2009; Salis et al., 2004). Whereas, silicone tubes provided more comfort for the patient and had less complications of phlebitis (Di Giacomo, 2009).

Materials and Method

Gastric residuals were examined across combinations of the variables of interest; composition of feeding tube material, type of feeding, and feeding tube size. The various interactions of the variables resulted in eight different combinations. Ten time trials were run for each of the variable combinations for a total of 80 time trials: 5Fr polyurethane/formula, 5Fr polyurethane/breast milk, 5Fr silicone/formula, 5Fr silicone/breast milk, 6.5Fr polyurethane/formula, 6.5Fr polyurethane/breast milk, 6.5Fr silicone/formula, and 6.5Fr silicone/breast milk. Feeding tube sizes selected for this study included 5Fr and 6.5Fr (Utah Medical Products Inc.®) silicone and polyurethane feeding tubes because these sizes are typically used with premature infants. The feedings selected for this study were Similac Special Care Premature Infant Formula 24 kcal/ounce (Abbott Nutrition®) and Human Breast Milk that was fortified with Similac Human Milk Fortifier Powder (Abbott Nutrition®) to obtain 24 kcal/ounce. Both of these enteral solutions are typical feedings for premature infants during their growing phase. The decision was made to infuse the volume that, when provided every three hours, represented the volume required to provide 120 kcal/kg/day to a premature infant weighing 1000 grams. Thus for each trial, 19 ml of the selected feeding was infused.

Each time trial was designed to simulate an actual infusion of a feeding to a premature infant. The selected feeding volume, 19mL, was infused using a 35mL syringe and infusion pump over a 20 minute time period. The 20-minute period was selected because it is the recommended time that a feeding should be provided to a premature infant. The infusion was collected in a 60mL beaker containing 2.8mL of HCl with a pH of 2.75. The 2.8mL of HCl at a pH of 2.75 are consistent with the amount and pH of HCl in a premature infant's stomach (Omari & Davidson, 2003). The beaker sat on a shaker plate to ensure even distribution of the HCl throughout the infused feeding. The feeding tube was taped to the beaker to ensure that the tip maintained a position below the level of HCl.

Once the feeding ended, the syringe was removed from the pump and used to aspirated contents from the beaker. Steady pressure was exerted for 30 seconds and volume was transferred to another beaker. This volume was then measured by 10 mL syringe to provide an accurate measurement of the aspirated volume and recorded. All materials were disposed after use and new materials were used for each trial. To maintain consistency of pressure exerted during aspiration, the same person aspirated all trials.

Data were entered into SPSS, version 19.0. Means and standard deviations were calculated for each of the variable combinations. Group differences were determined using independent *t*-tests.

Results

Data comparing silicone and polyurethane are presented in Table 1. Consistently across external tube size and feeding type, gastric residuals obtained using silicone feeding tubes resulted in significantly less volume being aspirated when compared to polyurethane ($p < .05$). Approximately 30-50% more gastric residual volume was obtained with polyurethane tubes.

Data presented in Table 2 describe the comparisons made between gastric residual volume obtained from Similac Special Care Preterm Formula and Fortified Human Breast Milk. These comparisons were made with feeding tube size and composition constant. With the exception of comparisons made using the 5Fr polyurethane feeding tube, significantly greater gastric residuals were obtained with Fortified Human Breast Milk when compared Special Care Preterm Formula ($p < .05$) across size and composition of feeding tubes.

Discussion

Preterm infants are at risk of developing feeding intolerance and NEC. Enteral feeding is initiated to maintain the nutritional needs of the preterm infant. Proper assessment by the nurse aids in the timely identification of such problems. Traditional methods of early identification of feeding intolerance include increased gastric residuals and poor feeding. Because many preterm infants are fed through the use of a nasogastric tube, the assessment of poor feeding cannot be determined so the use of increased residuals becomes a more important assessment tool.

This study found that material and size, as well as the contents infused, impact the amount of residuals aspirated. The silicone tube allows less residuals to be aspirated than the polyurethane tubes. Breast milk was easier to aspirate residuals than formula. Previous studies have found tube material affects comfort, burst pressures, and aspirate amounts.

Silicone tubes are thought to provide more comfort to the patient due to its flexibility. However, these very characteristics can cause disguise important assessment details. The internal diameter of silicone tubes are much smaller than polyurethane; only external diameter size is noted on the package in Fr. Due to their increased flexibility, silicone tubes collapse when negative pressure is exerted and affects the ability to aspirate gastric contents.

Many studies have supported that breast milk is best for the preterm infant. This study found that aspirating breast milk yielded a higher amount than formula, even when fortified. The consistency of breast milk is much thinner than formula allowing for more volume to be aspirated even when using silicone tubes.

Nurses, doctors, and other health care professionals need to be aware of what type of nasogastric tubes are used to ensure quality patient care to the preterm infant. Early detection of feeding intolerance can considerably lower costs of care and increase the health of the preterm infant.

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Table 1. Comparison of Silicone and Polyurethane

Feeding and Tube Size	Mean ±SD	Range	Significance
HBM 5Fr: Silicone Poly	7.04 ± 1.13 ml 11.56 ± 1.12 ml	5.4-8.6 ml 9.6-12.8 ml	.000*
HBM 6.5Fr: Silicone Poly	10.46 ± 0.71 ml 14.86 ± 2.14 ml	9.4-11.4 ml 10.8-18.4 ml	.000*
PF 5Fr: Silicone Poly	5.00 ± 0.99 ml 11.26 ± 1.51 ml	3.6-6.4 ml 9.0-13.2 ml	.000*
PF 6.5Fr Silicone Poly	6.20 ± 1.55 ml 11.94 ± 1.61 ml	3.6-8.8 ml 9.8-14.8 ml	.000*

Table 2. Comparison of Feeding Types

Tube Size Composition	Mean ±SD	Range	Significance
5Fr Silicone: HBM PF	7.04 ± 1.13 ml 5.00 ± 0.99 ml	5.4-8.6 ml 3.6-6.4 ml	.000*
6.5Fr Silicone: HBM PF	10.46 ± 0.71 ml 6.20 ± 1.55 ml	9.4-11.4 ml 3.6-8.8 ml	.000*
5Fr Poly: HBM PF	11.56 ± 1.12 ml 11.26 ± 1.51 ml	9.6-12.8 ml 9.0-13.2 ml	.621
6.5Fr Poly: HBM PF	14.86 ± 2.14 ml 11.94 ± 1.61 ml	10.8-18.4 ml 9.8-14.8 ml	.000*